KENDECOM VHF, UHF TRANSMITTER

420-520 MHZ

OPERATING MANUAL

ISSUE APRIL 1991

KENDECOM INCORPORATED

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DESCRIPTION

The MT450-B is a solid-state FM transmitter capable of operating on any crystal-controlled single-frequency in the 406-512 Mhz range. The MT450-B is engineered for high reliability to provide maintenance free operation in continuous-duty repeater and base station applications. The transmitter may be configured to operate output power levels of 2 watts or 15 watts.

Transmitter circuitry is contained on two printed wiring boards mounted in a 6-inch (15.2 mm) X 6-inch (15.2 mm) X 2-inch (5 mm) aluminum enclosure. One circuit board contains audio, modulator, oscillator, multiplier, and driver stages plus the low power (2-watt) amplifier. The second board contains the high power (15-watt) TMOS FET amplifier. All input leads and non-RF output leads entering the transmitter enclosure are bypass-filtered with individual feed-through capacitors. RF output energy is delivered through an enclosure-mounted type N coaxial connector.

Notices

The MT450-B transmitter is type accepted for operation under FCC Regulations parts 90 and 95. The transmitter may be operated only in accordance with an authorized station license issued under those regulations. Installation and adjustment of the transmitter must be done by a licensed technician.

Kendecom Incorporated limits its liability with respect to the ownership and operation of this equipment as described in the warranty section of this manual. By installing and/or operating this equipment the owner signifies acceptance of these limitations.

1.0 SPECIFICATIONS

Frequency range:	406 - 512 MHz
Power output:	2 watts in low-power mode 15 watts in high-power mode
Output amplifier:	TMOS FET in high-power mode. Capable of withstanding infinite VSWR
Frequency control:	Parallel resonant crystal (32pf load capacitance, HC-25/U holder) mounted in a proportionally controlled oven
Multiplication ratio:	24 X
Frequency stability:	+/- 0.00025% (-30° to +60°C)
Harmonic output:	Greater than 65 dB below rated output
Spurious output:	Greater than 70 dB below rated output
Noise output:	Greater than 90 dB below rated output in high-power mode at +/- 5MHz from output carrier frequency
Modulation:	Frequency modulation. Deviation adjustable to +/- 5 KHz
Audio Response:	Within +2 dB, -3 dB of EIA standard 6dB/octave pre-emphasis from 300 Hz to 2700 Hz
Audio Distortion:	Less than 2%
Power Requirements:	+12 VDC and +28VDC (in high power mode)
Duty Cycle:	Continuous
FCC Identifier:	D4DSNA-MT450B
Emission designator:	15F3

2. INSTALLATION

2.1 Operating Location

As with any electronic equipment, the reliability of the MT450-B transmitter will be enhanced by selecting a location which will not subject the unit to extreme environmental conditions. The location should be chosen such that the transmitter will not be exposed to moisture or corrosive atmospheres.

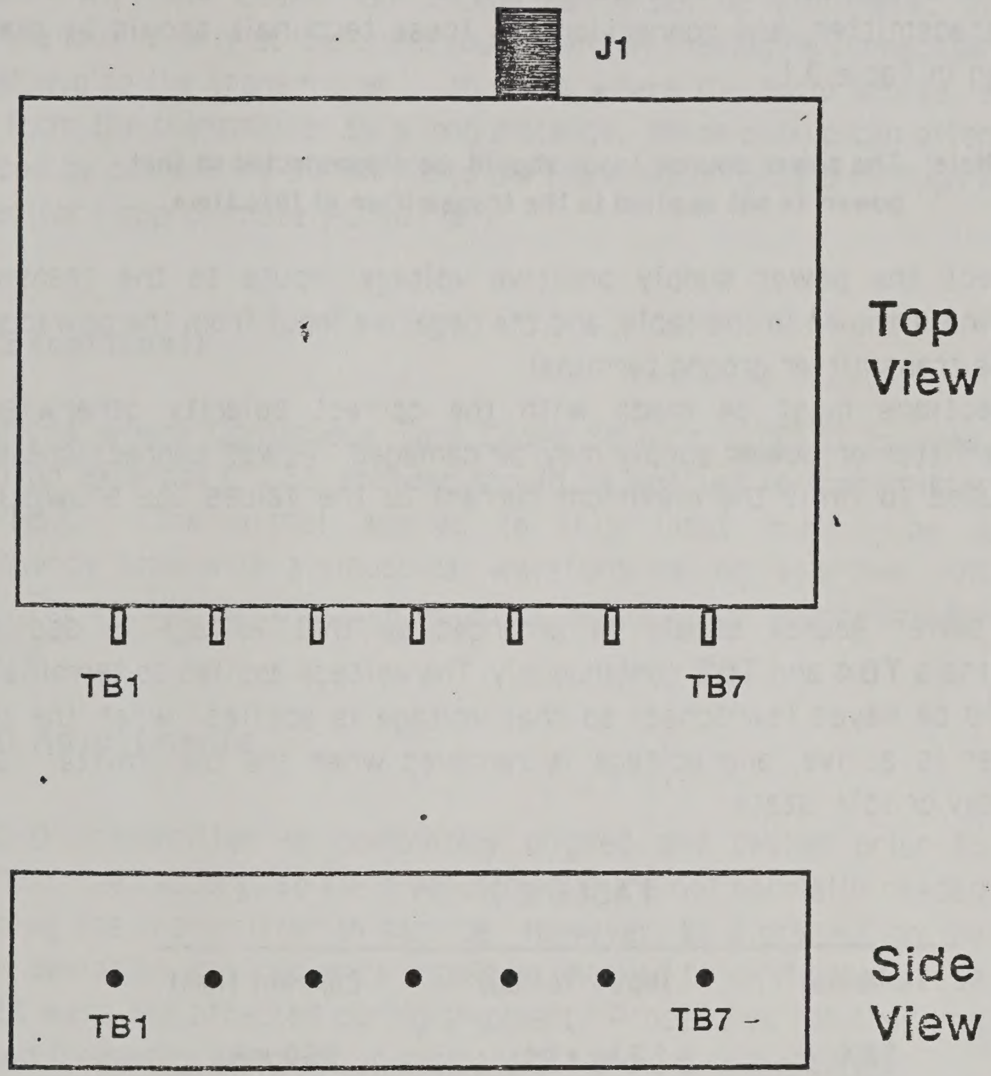
2.2 Mounting

The MT450-B may be mounted in any position. The mounting arrangement should allow sufficient clearance so that internal adjustments can be accessed by removing the top cover of the unit. The transmitter enclosure provides sufficient heat sinking in most cases. In those cases where ventilation is inadequate, the transmitter enclosure should be mounted firmly to an equipment rack panel or other supplemental heat sink to insure that the transmitter internal ambient temperature does not exceed 60° C.

Four mounting studs are provided on the bottom of the transmitter enclosure for holding the unit in place. The mounting studs accept standard 8-32 machine screws.

2.3 Connections - General

Non-RF connections should be made to the feed-thru capacitor terminals and ground terminal on the side of the transmitter enclosure. Connections may be made by soldering directly to the terminals. RF output is taken from a type-N coaxial connector which is also located on the side of the transmitter enclosure. Relative positions of the terminals and the coaxial connector are shown in figure 2.1.



Enclosure assembly showing terminal locations

2.4 Power Connections

Power for the MT450-B should be supplied from an external, well-filtered DC power source. Three separate power input terminals are provided on the transmitter, and connections to these terminals should be made as shown in Table 2.1.

> **Note: The power source input should be disconnected so that power is not applied to the transmitter at this time.**

Connect the power supply positive voltage inputs to the transmitter terminals shown in the table, and the negative input from the power supply to the transmitter ground terminal.
Connections must be made with the correct polarity otherwise the transmitter or power supply may be damaged. Power connections should be fused to limit the maximum current to the values the shown in the table.

The power source should be arranged so that voltage is applied to terminals **TB4** and **TB2** continuously. The voltage applied to terminal **TB5** should be keyed (switched) so that voltage is applied when the transmitter is active, and voltage is removed when the transmitter is in a standby or idle state.

TABLE 2.1

Terminal	Input Voltage	Current limit
TB4	+12 to +14	250 mA.
TB5	+12 to +14	500 mA.
TB2	+28 to +30	1.5 A.

2.5 RF Output

RF output from the transmitter is taken from a type N coaxial connector **J1**. Connection should be made from **J1** to a 50Ω antenna system using a 50Ω coaxial cable terminated in a type N coaxial connector. For proper operation, the antenna system VSWR should not exceed 1.5:1.

2.6 Audio Input

Audio input should be applied at an amplitude of approximately 500 millivolts peak-to-peak from a nominal 600Ω audio source. Connect the audio input to transmitter terminal **TB6**. Shielded wire should be used for

making this connection.

Grounding arrangements in some installations may cause hum and noise pickup on the wiring between the audio source and the MT450-B transmitter. In these cases hum pickup can often be eliminated by grounding the shield only at the audio source (and by making no connection from the shield to the transmitter.) In cases where the audio source is separated from the transmitter by a long distance, noise pickup can often be minimized by connecting the shield to the transmitter ground through a small capacitor (approximately 0.001 uF.)

2.7 CTCSS (optional)

In applications where Continuous Tone Coded Squelch (CTCSS) is used, audio from an external CTCSS encoder should be applied to transmitter terminal **TB7.** The signal applied to this input must be a single-frequency tone with a sinusoidal waveform having less than 10% distortion. The encoder should have an output amplitude of approximately 0.7 volts rms.

2.8 Initial Adjustments

The MT450-B transmitter is completely aligned and tested prior to shipment from the factory, so field adjustments are not normally needed before placing the transmitter in service. However, as a precaution the transmitter deviation and frequency should be checked to verify that these adjustments were not affected during shipment. Procedures for checking deviation and frequency are given in sections 3.1 and 3.3 respectively.

The transmitter is tuned at the factory to operate into a 50Ω resistive load. For proper operation, the antenna and/or duplexers connected to the transmitter should be adjusted to present a 50Ω termination to the transmitter. If the antenna system cannot be tuned to obtain an ideal 1:1 VSWR, a slight adjustment of the transmitter output amplifier stage may be necessary as described in section 3.5.

3. ADJUSTMENTS

3.1 Deviation Adjustment

The modulation level was adjusted prior to shipment from the factory to provide 5 kHz. deviation. The transmitter limiter will allow this full deviation level to be reached on voice peaks over a wide range of audio input levels. Transmitter deviation may be adjusted as follows:

Test equipment required:

- 600Ω sinewave audio oscillator
- Communications test set or modulation meter
- RF dummy load

Procedure:

1. Connect the audio oscillator to transmitter terminals TB6 (audio) and TB1 (ground). Adjust the audio oscillator to provide a 200 millivolt rms, 1000 Hz output signal.

2. Connect the transmitter RF output (J1) to the dummy load.

3. Apply operating DC voltages to the transmitter.

4. Measure the transmitter deviation using the modulation meter.

5. Use a fine bladed screwdriver to set the DEVIATION ADJUST (**R20**) to obtain 5 kHz deviation with the polarity which gives the highest reading on the modulation meter.

3.2 Audio Level Adjustment

Input audio level should be adjusted so that occassional voice peaks produce a full 5 kHz deviation. The transmitter limiter will prevent excessive transmitter for any audio input level setting; however, improper settings may degrade performance by emphasizing background noises. Transmitter deviation must be set (per section 3.1 above) prior to adjusting the audio level.

Test equipment required:

- Communications test set or modulation meter
- RF dummy load

Procedure:

1. Connect an amplified microphone or equivalent audio source to transmitter terminals **TB6** (audio) and **TB1** (ground).

2. Connect the transmitter RF output (**J1**) to a dummy load.

3. Apply operating DC voltages to the transmitter.

4. Speak into the microphone in a normal voice.

4. Measure the transmitter deviation using the modulation meter.

5. Adjust the input audio level control so that audio peaks indicate 5 kHz deviation on the modulation meter. DO NOT adjust the transmitter deviation setting.

3.3 Frequency Adjustment

Test equipment required:

- Frequency counter of 2 ppm accuracy
- RF dummy load

Procedure:

1. Remove the four screws holding the transmitter top cover and remove the top cover.

2. Connect the transmitter RF output (**J1**) to a dummy load.

3. Apply +12 volts DC to transmitter terminal **TB4**. Wait at least 2-minutes for transmitter component temperatures to stabilize.

4. Loosely couple an insulated wire loop from the frequency counter to the transmitter harmonic filter wire line.

5. Apply +12 volts to transmitter terminal **TB5**.

6. Rotate **C27** using an insulated tuning tool to set the transmitter to the correct frequency as indicated on the frequency meter.

7. Remove the wire loop and replace the transmitter top cover.

3.4 CTCSS Level Adjustment (optional)

In applications where Continuous Tone Coded Squelch is used, tone encoder amplitude should be adjusted to properly modulate the transmitter. Transmitter deviation must be adjusted (per section 5.1 above) prior to setting the CTCSS level.

Test equipment required:

- Communications test set or modulation meter
- RF dummy load

Procedure:

1. Connect the CTCSS encoder to transmitter terminals **TB7** (tone) and **TB1** (ground).

2. Connect the transmitter RF output (**J1**) to a dummy load.

3. Apply operating DC voltages to the transmitter.

4. Insure that no audio is being applied to transmitter terminal **TB6**.

4. Measure the transmitter deviation using the modulation meter.

5. Adjust the CTCSS encoder level to obtain an indication of 0.5 kHz deviation on the modulation meter. DO NOT adjust the transmitter deviation setting.

3.5 Alignment

The MT450-B transmitter is completely aligned prior to shipment from the factory. Re-alignment should not be necessary unless a component is replaced. Transmitter frequency (see 3.3) and modulation level (see 3.1) should be checked following alignment.

Test equipment required:

- 20,000 Ω/V multimeter having a 0-10 volt scale
- 0-2 A current meter
- RF dummy load
- RF power meter

Procedure:

1. Remove the four screws holding the transmitter top cover and remove the top cover.

2. Connect the transmitter RF output (**J1**) through the RF power meter to the dummy load.

3. Apply +12 volts to transmitter terminals **TB4** and **TB5**

4. Connect the multimeter between ground and each test point (**TP**) shown in table 3.4. Adjust the circuit components shown in the table to obtain maximum reading on the multimeter. Some interaction may occur, so repeat the adjustments as necessary until no further increase can be obtained in the multimeter reading.

If the transmitter is wired for high-power operation (15 watt output) follow steps 5 through 9. If the transmitter is wired for low-power operation (2 watt output) skip to step 10 to continue the alignment procedure.

The following step (step 5) sets the bias voltage of the final amplifier transistor (**Q101**). This adjustment is needed only if the transistor is replaced.

5. Remove the voltage from terminal **TB5** and apply +28 volts through the current meter to terminal **TB2**. Connect the multimeter to the input (gate) of amplifier **Q101**. Adjust potentiometer **R102** to obtain a voltage of 3.0 volts.

6. Connect +28 volts to terminal **TB2** and +12 volts to terminal **TB5**.

7. Connect the multimeter to terminal **TB3**. Adjust capacitors **C107**, **C108**, and **C109** to obtain maximum indication on the multimeter. Some interaction may occur, so repeat the adjustments until no further increase can be obtained in the multimeter reading.

8. Rotate the Power Adjust potentiometer (**R58**) to obtain the desired power output as indicated on the RF power meter. Observe the current meter to verify that the final amplifier current does not exceed 1.3 A. Adjust **R58** if necessary to prevent the current from exceeding 1.3 A.

9. Replace the transmitter top cover. This completes the alignment of the transmitter for high-power (15 watt) operation.

The following steps should be done to complete the alignment when the transmitter is wired for low-power (2 watt) operation.

10. Rotate the Power Adjust potentiometer (R58) to obtain a power output of 2 watts as indicated on the RF power meter.

11. Replace the transmitter top cover. This completes the transmitter alignment.

Table 3.4

Test Point	Nominal voltage	Adjust Components
TP3	4 VDC	L2, C43, L3, C46
TP4	4	L4, C52, L5, C54
TP5	6	L6, C58, L8, C61
TP6	2.2	L10, C67, L11, C69

4. CRYSTAL

4.1 Crystal Specifications

The MT450-B transmitter is shipped from the factory with the frequency controlling crystal installed and with the transmitter tuned to frequency. If the transmitter frequency is to be changed the replacement crystal unit should conform to the following specifications.

Crystal frequency = (Transmitter operating frequency) / 24

Mode: Parallel resonant, 32 pf load capacitance

Type: High-accuracy, 60°C turnover, HC-25/U holder

4.2 Crystal Replacement

1. Remove all power from the transmitter.

2. Remove the four screws holding the transmitter top cover and remove the cover.

3. Remove the four screws holding the exciter circuit board and carefully lift the circuit board to gain access to the foil side of the board.

4. Locate the crystal heater unit and observe the orientation of the heater

unit. Unsolder the two wire leads holding the heater unit to the circuit board and remove the heater unit.

> **Caution:** Use a fine-pointed, temperature controlled soldering iron and a solder wick or desoldering tool. Apply the minimum heat necessary. Do not exert excessive stress on component leads.

5. Unsolder the two wire leads holding the crystal unit and remove the crystal.

6. Solder the new crystal unit in place, and then solder the heater unit in place. Be sure to position the heater unit in its original orientation.

7. Replace the exciter circuit board and secure it in place with the mounting screws.

This completes the crystal replacement procedure. Follow the procedure in section 3.3 to set the transmitter frequency.

5. LOW POWER OPERATION

The MT450-B transmitter can be arranged to operate in a low power mode for use in applications where the maximum permitted output power is 2 watts. The wiring changes needed to operate in the low power mode are given below. These wiring changes are made at the factory when the low power option is ordered. The power amplifier board is not functional in the low power mode, therefore, this board is not furnished in units which are factory wired with the low power option.

> **Caution:** Remove power from the transmitter before making wiring changes.

1. Remove the coaxial cable connecting from the power amplifier board to RF output coaxial connector **J1**.

2. Locate the coaxial cable connecting from terminal **E6** on the exciter board to terminal **E101** on the power amplifier board, and disconnect the end of the cable which is connect to terminal **E101**.

3. Connect the free end of the coaxial cable to the RF output coaxial connector **J1**.

Power amplifier stage **Q101** is not used in the low power mode; therefore, no power connection should be made to terminal **TB2**. After the wiring changes are made, the transmitter should be aligned in accordance with the procedure given in section 3.5 for low opower operation. Power Adjust

potentiometer **R58** should be used to set the transmitter output power to 2 watts.

6. CIRCUIT DESCRIPTION

6.1 Audio Amplifiers

Input audio is applied to the transmitter through feedthru capacitor **TB6** which removes any RF energy present on the input audio wiring. Additional RF bypassing is provided by capacitor **C1**. Audio input impedance is established as 1KΩ by resistor **R1**. Audio signals are amplified in two operational amplifiers, **U1A** and **U1B**. Each amplifier section provides a gain of 20 dB. The two amplifier stages are AC coupled, and the output of each amplifier stage is biased at level of +6 VDC. Feedback is provided by capacitors **C3** and **C6** to control the frequency response of the amplifiers. Supply voltages to the amplifiers are decoupled to prevent noise pickup with ferrite bead **FB2** providing high-frequency decoupling and **R7/C7** providing low-frequency decoupling. Amplifier bias is established by resistive divider **R2** and **R3** with bead **FB1** and capacitor **C4** providing decoupling for the bias divider. Audio output from the second stage amplifier is applied to the limiter stage through resistor **R9**.

6.2 Limiter, post limiter filter

Integrated circuit **U2A** contains an audio amplifier and a variable gain cell which serves as both a compressor and peak limiter. Input audio is applied to pin 5 of **U2A** and output audio is taken from pin 7. DC feedback is provided by **R11** and AC feedback is provided by **C10** in combination with the internal circuitry of **U2A**. The gain of **U2A** is determined by the voltage present on capacitor **C13**. At low audio levels the voltage present on **C13** is small so **U2A** operates as a linear amplifier. The output of **U2A** is sampled and further amplified by **U3**. The output of **U3** is fed to **Q1**. At high audio levels, **Q1** causes the voltage across capacitor **C1** to increase which, in turn, reduces the gain of **U2A**. The adjustable gain cell in U2A operates in a logarithmic manner to accommodate a wide dynamic range of audio levels. In typical operation where the transmitter deviation is set to a maximum of 5 kHz deviation, U2A will function as a linear amplifier for audio levels which produce less than 4.8 kHz deviation. Compression will begin at levels which produce 4.8 kHz deviation and hard limiting will occur at levels which produce 5 kHz. deviation. In the hard limiting region, the output is held constant for input overdrive levels greater than 30 dB.

The output of **U2A** is fed to Deviation Adjust potentiometer **R20** and then to the post limiter audio filter consisting of **R21**, **R22**, **R23**, **C15**, **C16**,

C17, and C19 The post limiter filter provides a minimum of 18 dB per octave rejection of signals above 3kHz. The output of the post limiter filter is fed to voltage amplifier Q2 which drives varactor diode CR1 to deviate the transmitter frequency.

6.3 Oscillator, buffer

Transistor Q3 and associated components form a Colpitts oscillator. Feedback to sustain oscillation is provided by capacitors C33 and C34. Stable silver mica capacitors are used to maintain a precise feedback ratio. The voltage applied to Q3 is maintained precisely by voltage regulator VR1 to enhance oscillator stability. The frequency of the oscillator is determined primarily by crystal Y1. Capacitors C28A, C28B, and variable capacitor C27 are placed in series with the crystal and permit the transmitter frequency to be adjusted in a small range about the resonant frequency of the crystal.

Direct frequency modulation is obtained by applying an audio voltage to varactor diode CR1 which is also placed in series with the crystal. Audio signals are applied to the varactor diode from voltage amplifier Q2 through resistor R30. The applied audio voltage causes a corresponding change in diode capacitance which, in turn, causes deviation of the oscillator frequency.

Crystal Y1 and varactor diode CR1 are mounted in a proportional oven which maintains both components at a constant temperature to prevent variations in ambient temperature from changing transmitter frequency.

Output from the oscillator is fed through capacitor C35 to buffer amplifier Q4. The buffer amplifier acts as a constant load to isolate the oscillator from variations in loading as the multiplier stages are tuned. A test point, TP1, is provided at the emitter of buffer amplifier Q4. A nominal voltage of 1.7 VDC at this test point signifies that the oscillator and buffer stages are operating properly.

6.4 Multipliers

Four stages are used to multiply the oscillator fundamental frequency to the final output frequency. The four stages comprise a total multiplication ratio of 24. Each stage consists of a transistor followed by a double-tuned interstage filter. Double-tuned interstage networks provide increased rejection of unwanted harmonics compared with single tuned networks. In addition, the double-tuned stages give reduced sensitivity to temperature variations and component ageing. The four

multiplier stages are as follows:

Multiplication Ratio	Transistor	Output Frequency Range in MHz	Interstage Filter
3	Q5	50.5 - 64	L2,C43,L3,C46
2	Q6	101.5 - 128	L4,C52,L5,C54
2	Q7	203 - 256	L6,C58,L8,C61
2	Q8	406 - 512	L10,C67,L11,C69

Test points are provided at the emitter of each multiplier stage to aid in alignment and troubleshooting. DC voltage measurements made at any test point are used to align the double-tuned networks of the preceding multiplier stage as described in section 5.4.

6.5 RF Amplifiers

Amplifiers Q9, Q10, and Q11 operate at the transmitter output frequency. Q9 is a pre-driver amplifier with a single-tuned output network consisting of L12, and C74. Series capacitor C75 and shunt inductor FB19 provide impedance matching from the output of Q9 to the input of driver stage Q10. Test point TP6 is provided at the emitter of Q9 to aid in the alignment of the preceding doubler stage. Transmitter power output can be set by using R58 to adjust the collector voltage of Q9.

Amplifier transistor Q10 provides drive to the final low-power output stage Q10 is tuned by L16 and C78 to operate at the transmitter output frequency. Series capacitor C79 and shunt inductor FB20 provide impedance matching from the output of Q10 to the input of amplifer Q11.

Amplifier transistor Q11 increase the transmitter power level to the 2-3 watt range. When the transmitter is wired for low-power operation, the output power may be set precisely to 2 watts by adjusting the drive level to Q11. When the transmitter is wired for high-power operation, Q11 operates at an output level of about 3 watts. The tuned output network of Q11 consists of inductors L20 and L11, and capacitors C86, C87, and C88. This output network provides both low-pass filtering and impedance matching to a 50Ω load. A shunt feedback network consisting of L18, C83, and R63 reduces low-frequency gain to prevent spurious oscillations.

6.6 Power Amplifier

For high-power operation TMOS FET power amplifier transistor Q101 raises the transmitter output power to 15 watts. Q101 operates at a

nominal drain supply voltage of +28 volts and a gate bias of 3 volts. The gate bias is provided by using voltage regulator **CR101** to develop a stabilized supply voltage and potentiometer **R102** to compensate for variations in transistor characteristics. The input of **Q101** consists of a stripline filter tuned by capacitor **C107**. The mechanical arrangement of the stripline causes it to function as a distributed tuned filter. The output of **Q101** is tuned by a similar stripline arrangement operating in conjunction with capacitor **C108**. Capacitor **C109** provides impedance matching to the output harmonic filter. The harmonic filter is a four-section network which provides excellent harmonic rejection. Output power is sampled by capacitor **C114** and rectified by diode **CR102** to provide an indication of relative output power level at terminal **TB3**.

6.7 Power Distribution

The MT450-B has three separate power supply inputs: a continuous +12 volt input, a switched (keyed) +12 volt input, and a continuous +28 volt input. The continuous +12 volt input powers buffer **Q4** directly, and is regulated down to +8 volts by **VR1** to power oscillator **Q3** and the crystal heater. Multiplier, driver, and amplifier stages **Q5** through **Q11** are powered from the switched +12 volt supply. The +28 volt supply powers output amplifier transistor **Q101**. Transistor **Q101** and, consequently, the +28 volt supply are used only when the transmitter is wired for high power operation. Substantial power supply decoupling, in the form of RLC filter networks, are used on all active stages.

7. MAINTENANCE

The MT450-B transmitter is designed and constructed for reliable operation and long-life. Periodic maintenance is not required.

- If the transmitter fails to operate, verify that the three power supply voltage sources are connected to the transmitter and that the correct voltages are being supplied. Also verify that the transmitter is properly grounded.

- The transmitter can be damaged by lightning induced surges. Failure of the transmitter to draw current from the +28 volt supply is an indication that amplifier **Q101** may have been damaged by a lightning surge.

- If no RF power is obtained from the transmitter, use a DC voltmeter to verify that proper voltages are present at the test points. An improper voltage indicates a fault in the stage being measured or the preceding stage. Measurements should be made sequentially beginning with **TP1**

Limited Warranty

Kendecom Incorporated warrants to the original purchaser that this equipment shall be free of defects in material and workmanship for a period of one year from the original date of purchase.

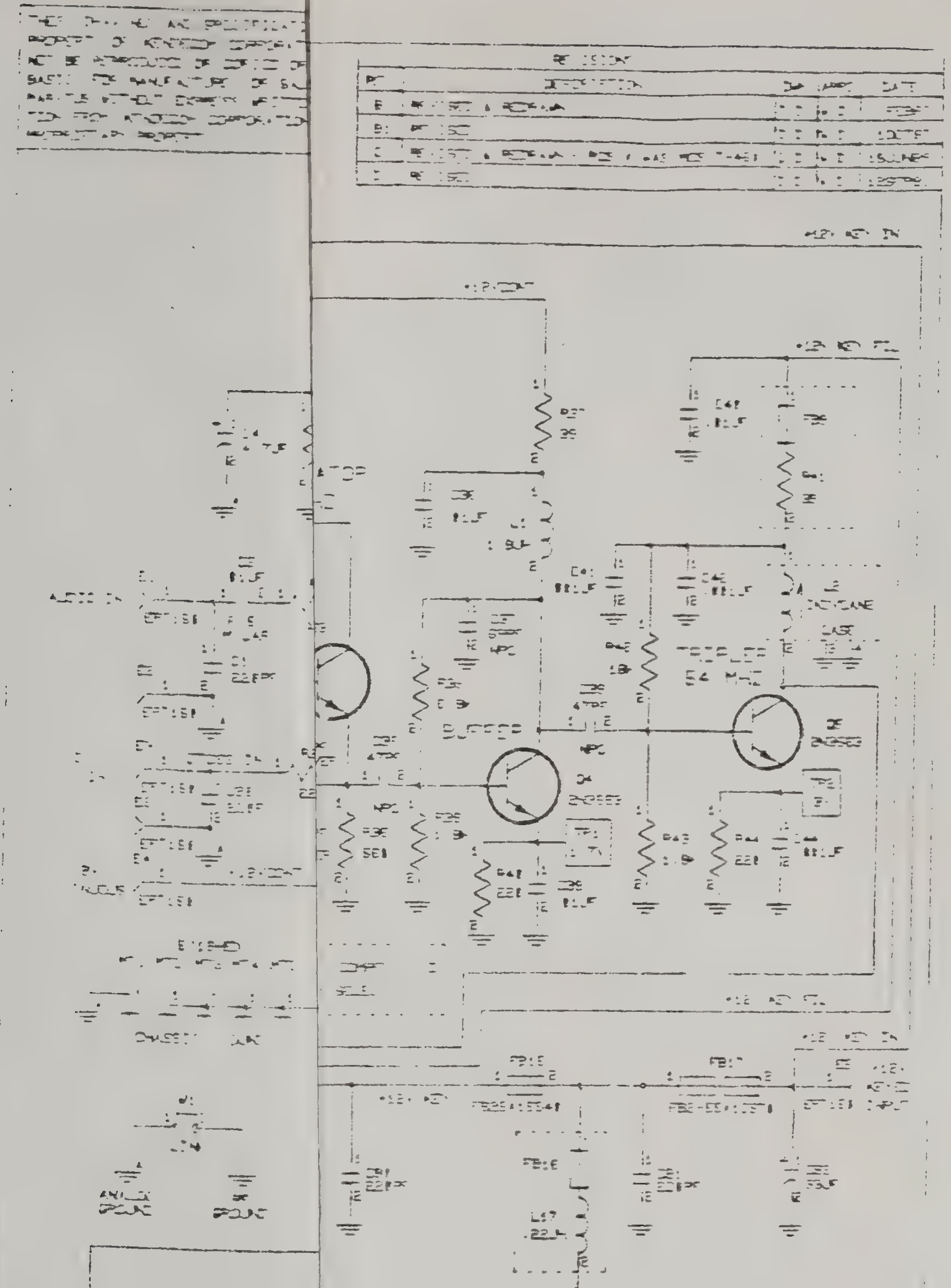
During the warranty period Kendecom Incorporated will provide any parts necessary to correct said defects provided the unit is delivered by the original owner intact to us for our examination and provided that our examination discloses that the unit is defective.

This warranty does not apply to any unit which has been subjected to misuse, neglect, accident, improper installation, incorrect maintenance, or use in violation of instructions furnished by us, nor to any unit which has been modified or used with accessories not recommended by us.

The foregoing constitutes the entire obligation of Kendecom Incorporated with respect to this product and no employee or officer of Kendecom or its dealers or distributors shall have the authority to extend this warranty. The buyer agrees that no other remedy for incidental or consequential damages, injury to person or property, or other loss shall be available. Some states do not allow limitations on how long an implied warranty lasts or on consequential damages so the above limitations may not apply to you.

The installation, operation, and maintenance of this unit may require licensing by the Federal Communication Commission or other regulatory agencies, and may require that adjustments to the unit be made by a licensed technician. The proper and legal operation of this unit is the responsibility of the owner.

Kendecom Incorporated reserves the right to make changes and improvements to its products without notice and without obligation to install such changes into previously sold products.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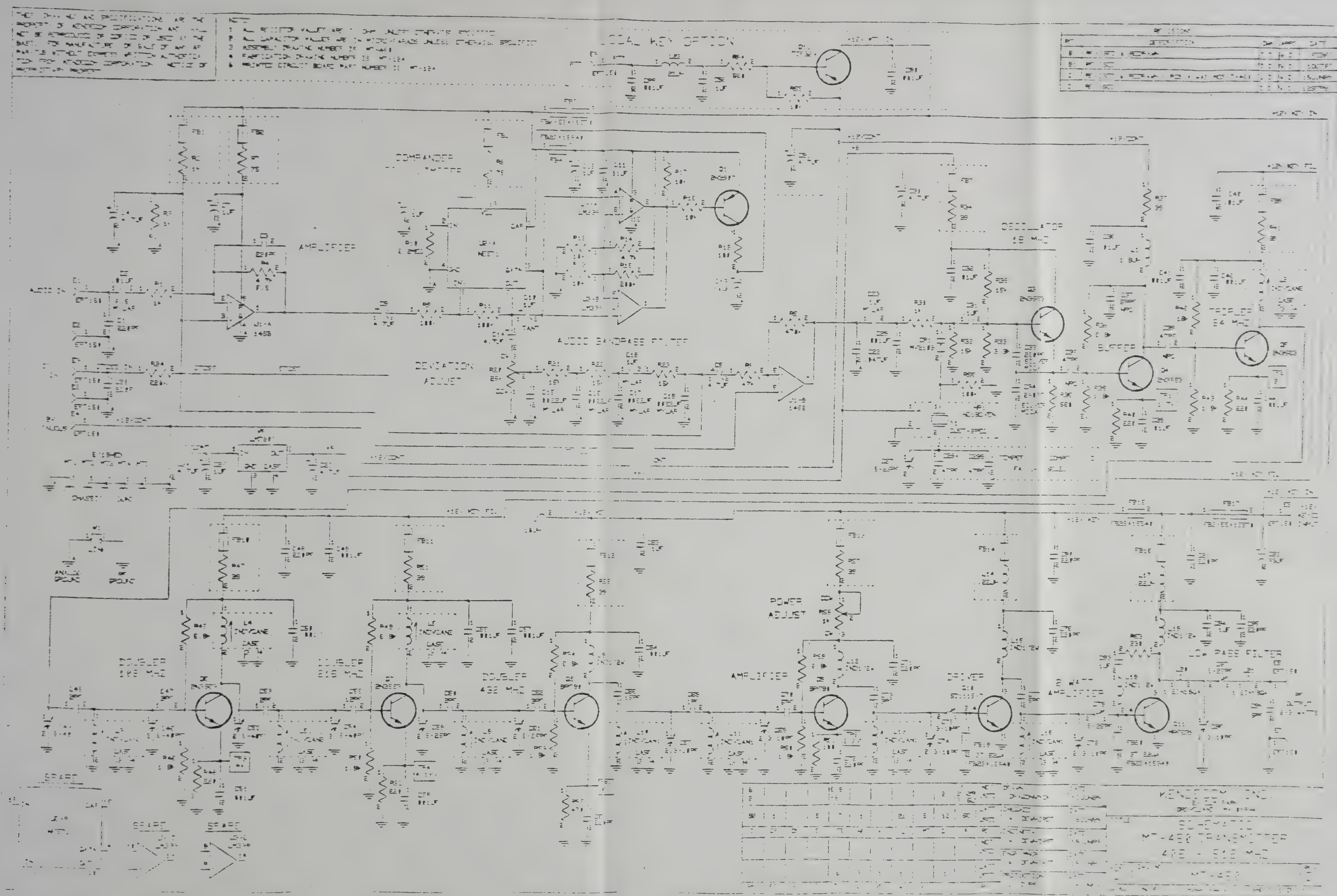
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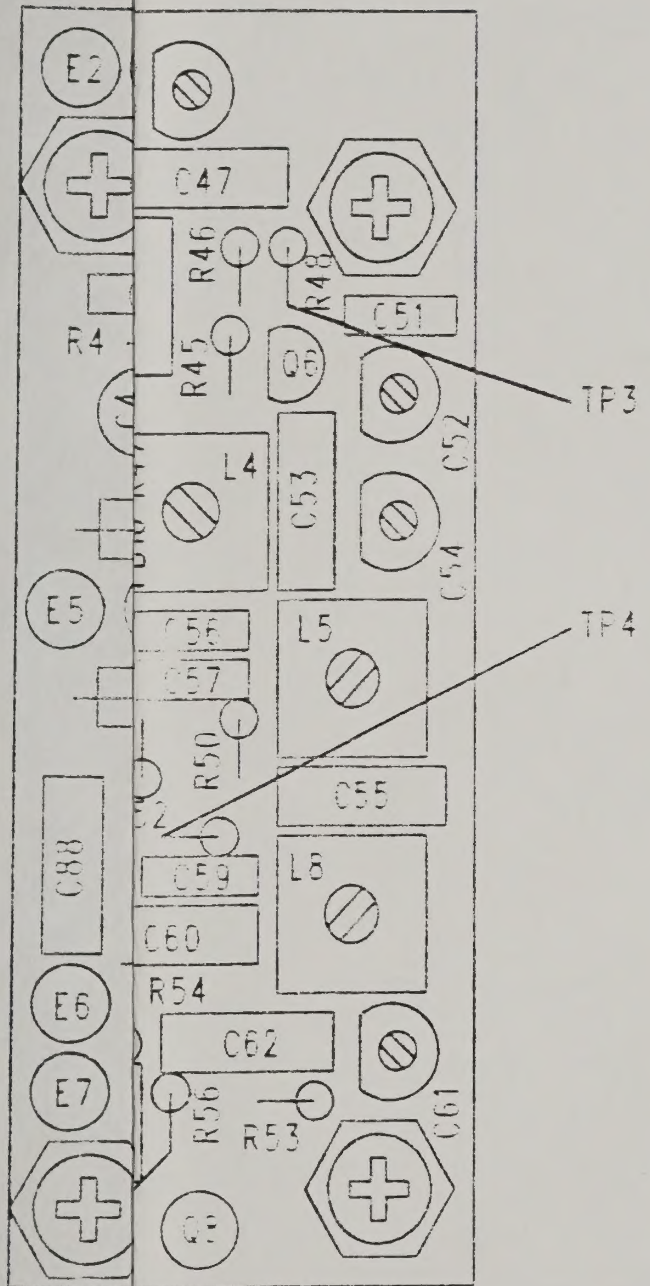

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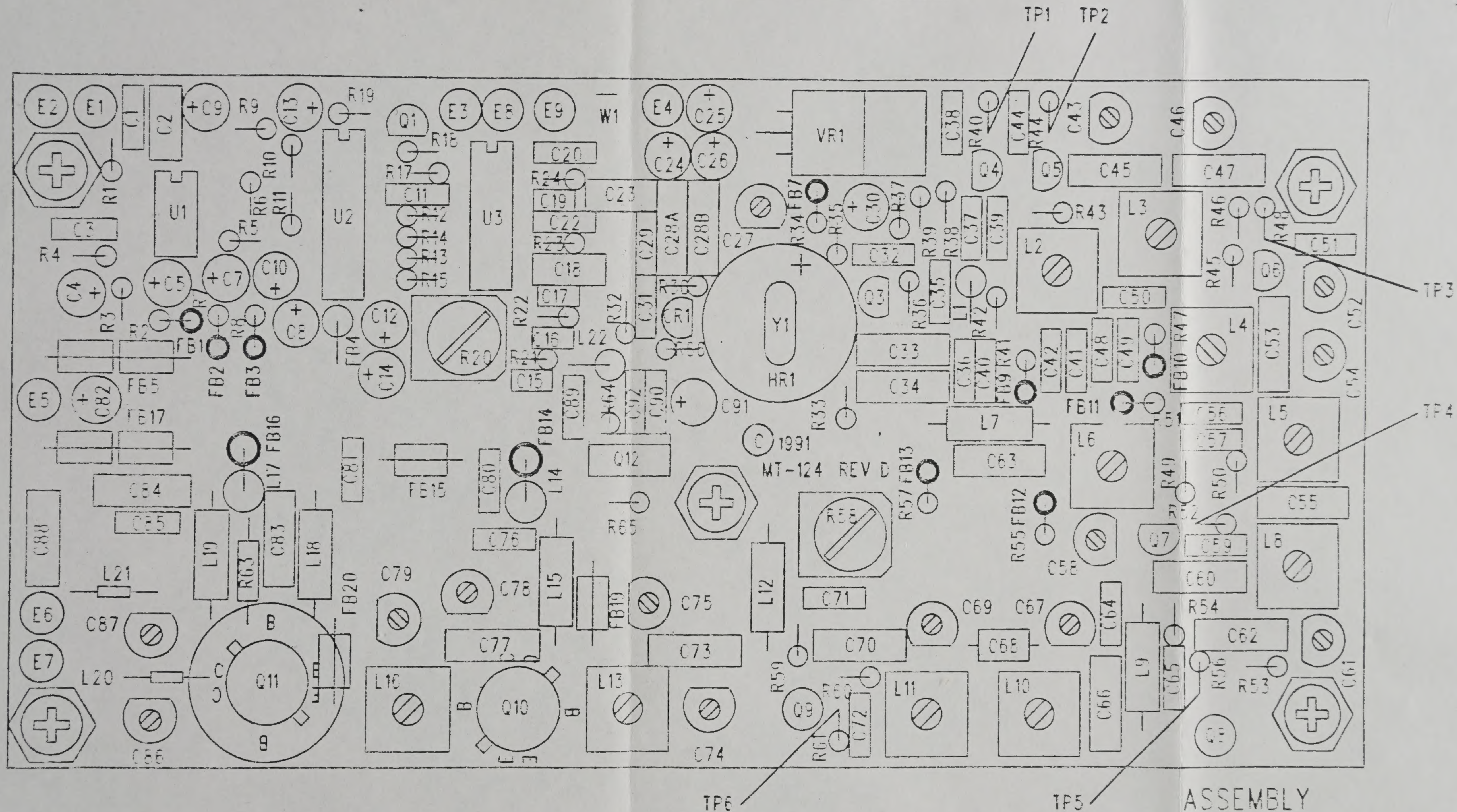

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